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OSTENFELDIELLA, A NEW GENUS OF PLASMODIOPHORACEAE

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Ostenfeldiella, a New Genus of Plasmodiophoraceae.

BY

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With Plate XLV and four Figures in the Text.

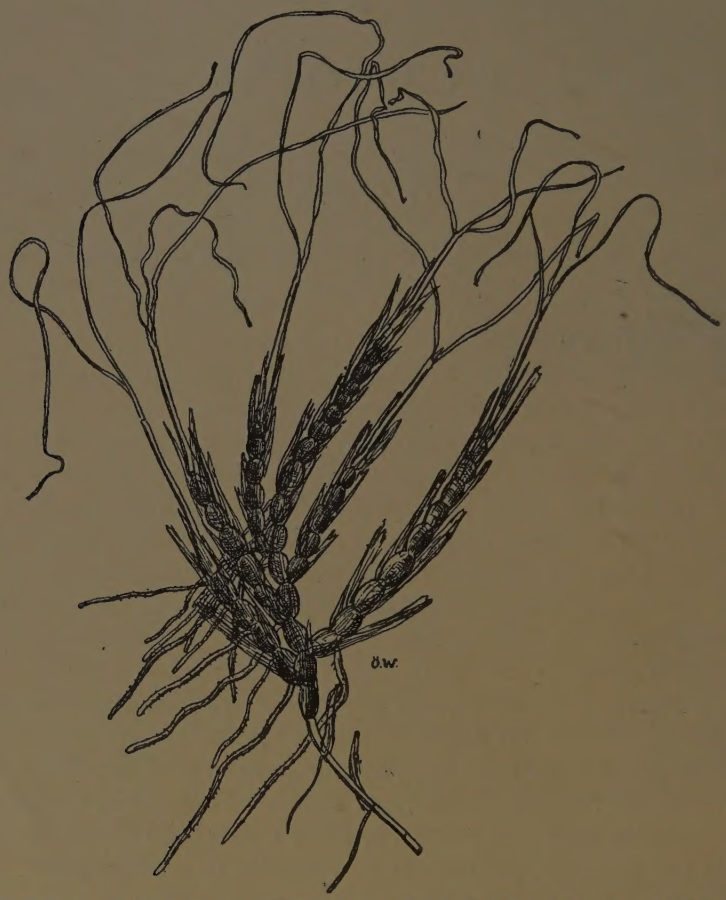
DURING a stay in the Danish West Indies in the winter 1913–14 Dr. C. H. Ostenfeld was studying *Diplanthera Wrightii*, Aschers., a Potamogetonacea, growing in shallow water on muddy soil on the coast of the island of St. Croix. This plant has a horizontal monopodial rhizome with partly stretched, partly shortened internodes, some of the latter being barely half a millimetre in length. From the rooting nodes branches are sent out in horizontal and upward directions. Dr. Ostenfeld noticed that sometimes the shortened internodes of the ascending branches, which are clothed with the sheaths of the linear alternating leaves, were conspicuously thickened, their diameter being about two to three times that of the normal ones, and the whole branch thereby bearing a certain resemblance to a string of pearls (Text-fig. 1). Dr. Ostenfeld found the swellings to be due to a Plasmodiophoracea, and after his return from the West Indies he placed his material at our disposal for closer investigation.

We regret not to have been able entirely to elucidate the cytology of the fungus, the material being fixed in alcohol only. On the other hand, the preservation was good enough to allow a thorough investigation of the ordinary biology of the parasite, and its relation to the host plant.

The Anatomy of the Normal Diplanthera Stem.

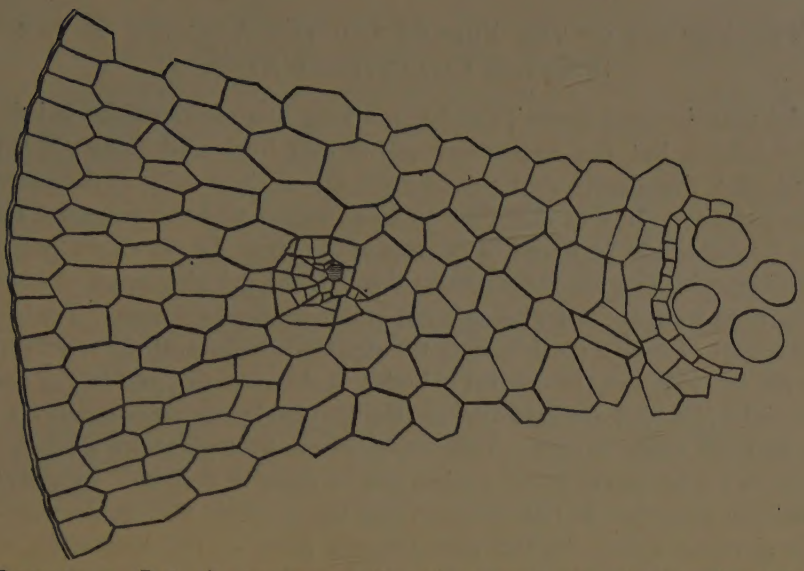
In order to determine the anatomical changes called forth by the fungus, we first studied sections of the normal stem. Text-fig. 2 shows a part of a transverse section through one of the shortened internodes of an ascending normal axis. In the middle of the stem is seen the central cylinder surrounded by the endodermis. The relations are diagrammatically represented

in Text-fig. 3 (the vascular tissue bundles are not filled in), where four phloem groups are seen round a narrow central lacuna. In the cortex is seen a difference between the inner and the outer part. The inner cortex has polyhedral, nearly isodiametric cells, about 35 μ across, while the cells of the outer cortex are radially stretched. On the limit between the two tissues is seen a small vascular bundle (Text-fig. 2), whereof a few may be found

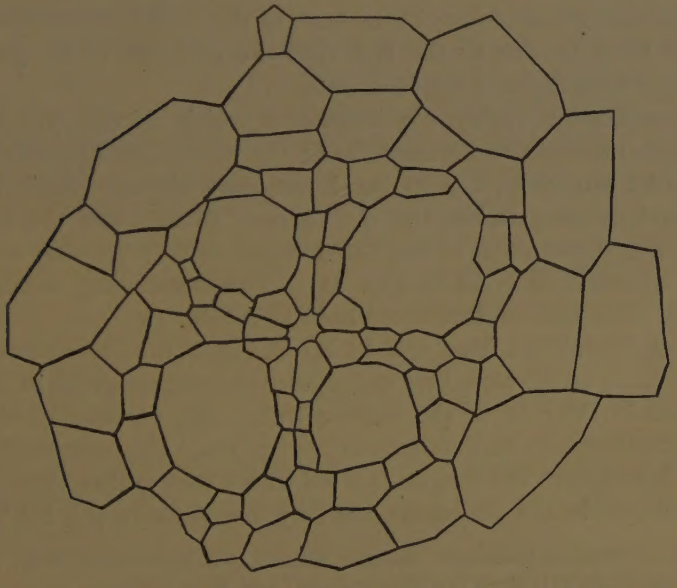


TEXT-FIG. 1. Habit sketch of *Diplanthera Wrightii*, infected by *Ostenfeldiella Diplantherae*. Natural size.

scattered in the stem. Intercellular spaces are lacking both in the cross-section (Text-fig. 2) and in the longitudinal section (Text-fig. 4), which is cut just under the apex of the stem. We have observed, however, narrow intercellular spaces measuring only the diameter of a single cell on the limit between the inner and the outer cortex; they are also present in the leaves, where they are interrupted by narrow cell-bridges.



TEXT-FIG. 2. Part of a transverse section of a normal stem of *Diplanthera Wrightii*. To the right the central cylinder with four phloem groups, surrounded by the endodermis. In the cortex two layers can be distinguished, the inner having nearly isodiametric, the outer radially elongated cells. On the limit of the two tissues is seen a cortical strand. × 200.



TEXT-FIG. 3. Transverse section through the central cylinder of the stem of *Diplanthera Wrightii*. Four phloem groups (not filled in) are seen surrounding a small central channel. Outside, the endodermis cells of the inner cortex. × 435.

The Biology of the Fungus and the Anatomy of the infected Diplanthera Stem.

As may be seen from Text-fig. 1, a long row of internodes is infected by the fungus, but the uppermost one is still fresh and living; it is thus evident that the shoots continue to grow in length in spite of the presence of the parasite. It was therefore to be expected that the youngest stages of our fungus might be found in the top of the stem, for which we prepared some slides with longitudinal sections through the growing apex of a shoot. The sections were stained with safranin-anilin-blue-goldorange. Text-fig. 4 shows a part of such a section, only the right side being entirely represented. Near the left side lies the central cylinder of the stem (*a*), and in the cortex to the right (*b* and *c*) are seen the two tissues previously mentioned, viz. the inner and the outer cortex. The nuclei of the host plant are shaded. In some cells are seen very small circles, one or more in each cell, representing uninucleate amoebae of the parasite, and these occur also in the very top of the growing zone. In the meristematic parts of the stem one always finds these amoebae uninucleate, hence it becomes evident that the nuclear divisions of the parasite are always followed by division of the myxoplasm itself—a fact that seems to be very rare in the Plasmodiophoraceae, these organisms having commonly a tendency to become plurinucleate very soon after infection.[1] Further, we must suppose that this occurrence of a single or a few uninucleate amoebae in the cells of the meristematic tissues of the host plant must be due to the fact that the divisions of the parasite are keeping pace with those of the host cells.

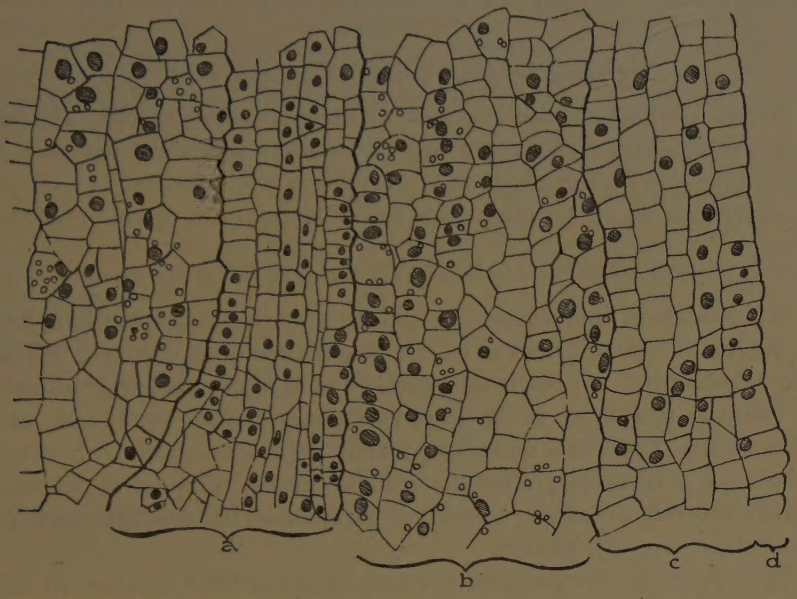
The uppermost embryonic internode, which is not yet deformed, contains only uninucleate myxamoebae; the next, slightly swollen, but yet light-coloured internode, has in the lower part already pluri- to many-nucleate myxoplasms; while the sporogenous plasms and the spore-balls are, as a rule, found only in the third conspicuously swollen and brown-coloured internode (Pl. XLV, Fig. 2). The succeeding internodes are completely filled with mature spore-balls (Text-fig. 4).

As seen from Text-fig. 4 and Pl. XLV, Fig. 4, the parasite only infects the inner cortex of the stem,[2] no myxamoebae being met with in the central cylinder nor in the cells of the outer cortex. The vascular bundles in the cortex seem always to be free from myxamoebae. The outer cortex, which, as stated, is free from the fungus, is filled with starch grains, these latter not being developed in the tissue attacked by the parasite (Pl. XLV, Fig. 3).

[1] The same is stated for *Sorosphaera Veronicae*, Schroet., by R. Maire and A. Tison: La Cytologie des Plasmodiophoracées et la classe des Phytomyxinées (Ann. Myc., 1909).

[2] Also in the host plants of *Sorosphaera Veronicae*, Schroet., and *Sorodiscus Callitrichis*, Lagerh. et Winge, the epidermis and the outermost layers of the cortex are free from the parasite, the central cylinder however being sometimes infected. Ö. Winge: Cytological Studies in the Plasmodiophoraceae. Archiv f. Botanik, vol. xii, no. 9, 1912, p. 18.

The infected cells grow to an abnormal size (Pl. XLV, Fig. 4), reaching about 125–200 μ across, the normal ones measuring only 35 μ, and their nuclei are dissolved towards the beginning of the sporogonic stage (Pl. XLV, Fig. 3). The mature spores have a brown and rather thick membrane, their diameter being about 4 μ. The spore masses entirely fill every infected cell as in the case of *Plasmodiophora* (Pl. XLV, Figs. 3, 4). By the pressure of the giant cells the elements of the surrounding outer cortex become stretched tangentially (Pl. XLV, Fig. 4), whereas normally they are radially elongated (Text-fig. 2). Unilateral attacks may occur, the central cylinder thereby being laterally displaced—in extreme cases almost



TEXT-FIG. 4. Part of a median longitudinal section just under the growing apex of an infected *Diplanthera* stem. *a*, the central cylinder; *b*, the inner cortex; *c*, the outer cortex; *d*, the epidermis. The nuclei of the host plant are shaded. Uninucleate amoebae of *Ostenfeldiella* (represented by small circles) are seen only in the cells of the inner cortex. × 300.

to the periphery of the stem. As a rule the diameter of the infected internodes is enlarged to two to three times that of the normal ones, these latter being commonly about 1 mm. across.

The above-mentioned characteristic localization of our fungus in the tissues of *Diplanthera Wrightii* explains the fact that an infected stem can keep on growing in spite of the parasite. The central cylinder, as well as the outer cortex, escapes the attack; hence the transport of nourishment, assimilation, and respiration are not disturbed by the parasite.

The common picture of the attack, we suppose, must be painted as follows: Zoospores are swarming in the mud and penetrate the young apex of a *Diplanthera* stem, until the initials of the inner cortex are reached.

Here they divide, spreading only in the daughter-tissue of these initials, and being unable to reach either the outer cortex or the central cylinder. A rich intravaginal branching of the stem taking place near the growing apex, the branches naturally are in danger of being infected, and as Text-fig. 1 shows, this condition occurs, and may be supposed to be the rule.

Finally we give a diagnosis of the parasite, which is, no doubt, a real Plasmodiophoracea. In honour of Dr. C. H. Ostenfeld, who discovered the fungus, and who also on former occasions has contributed to the knowledge of these organisms,[1] we associate his name with our fungus, naming it:

Ostenfeldiella, Ferd. et Wge. gen. nov.

Genus caulicolum, submarinum Plasmodiophoracearum, *Plasmodiophorae* propius accedens, colore autem saturato sporarum nec non modo crescendi proprio satis distinctum. Etymologia a cl. doctore C. H. Ostenfeld, fungi inventore, de studio plantarum maris vascularium optime merito.

Ostenfeldiella Diplantherae, Ferd. et Wge. sp. nov.

Myxamoebae uninucleatae in partibus merismaticis caulium hospitis nunc singulatim, nunc plures in cellula singula inventae, corticem interiorem solum infestantes. Ad basim internodii secundi myxamoebae plurinucleatae sese formare incipiunt, et in internodiis sequentibus sporosori, cellulas pluries auctas, 125–200 μ diametro, totum implentes, iacent. Sporae globosae, 4–4½ μ diametro, siccitate collabescentes, singulatim brunneolae, gregatim saturate brunneae, membrano satis crasso indutae, plasmate oleoso, flavescenti, refringenti farctae.

In internodiis brevibus caulium ascendentium limo sepultorum *Diplantherae Wrightii* Aschers., qui aggressu fungi ad modum siliquae *Ornithopodis sativi* usque ad 3 mm. diametro intumescunt, ad litus insulae St. Crucis Indiae occidentalis (Leg. C. H. Ostenfeld).

COPENHAGEN,
May, 1914.

[1] See Ö. Winge, l. c., p. 16, and C. Ferdinandsen et Ö. Winge: *Plasmodiophora Halophilae* sp. nov. Centralbl. f. Bakt., Parasitenk. u. Infektionskr., Bd. xxxvii, 1913, p. 167.

EXPLANATION OF PLATE XLV.

Illustrating Messrs. Ferdinandsen and Winge's paper on Ostenfeldiella, a New Genus of Plasmodiophoraceae.

The figures are all microphotographs.

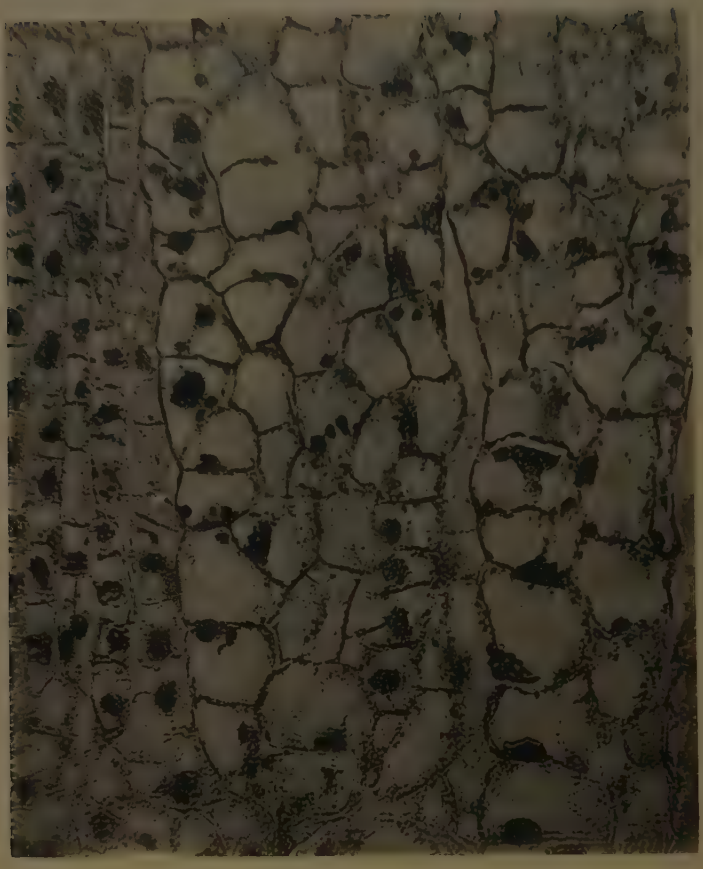
Fig. 1. Part of a median, longitudinal section just below the growing apex of a *Diplanthera* stem infected with *Ostenfeldiella Diplantherae*. Cf. Text-fig. 4. To the left the central cylinder; to the right the inner cortex, where the small amoebae of the parasite are to be seen. × 600.

Fig. 2. Longitudinal section on the limit between the second and the third internode (from the apex) of an infected *Diplanthera* stem. In the second internode (above) are seen only plurinucleate myxoplasms, whereas in the third internode (below) sporogenous plasms and spore masses have been developed. × 40.

Fig. 3. Part of a longitudinal section through an infected *Diplanthera* stem. Giant cells from the inner cortex with sporogenous plasms or spore masses. The nuclei of the host plant are about to be dissolved. To the left the unaffected cells of the outer cortex with starch grains. × 325.

Fig. 4. Part of a transverse section through the infected *Diplanthera* stem. The giant cells of the inner cortex are filled with spore masses of *Ostenfeldiella* (in some cells dropped out), whereas the central cylinder, as well as the outer cortex and the epidermis, is free from the parasite. × 50.

Fig. 5. Mature spores of *Ostenfeldiella Diplantherae*, partly collapsed from the action of the fixing agent, 90 per cent. alcohol. × 950.



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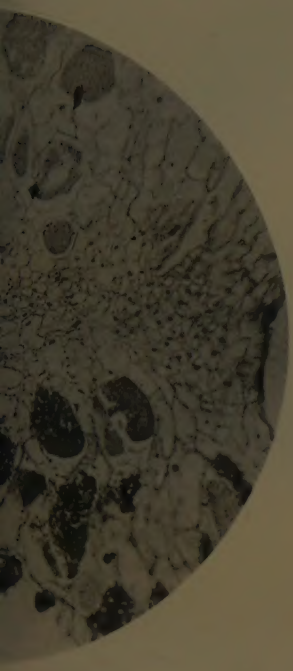

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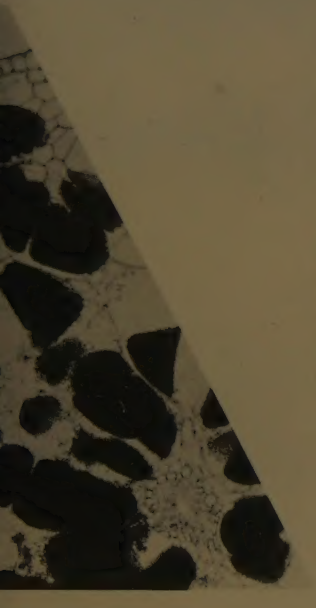

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